

# Second Project Review meeting

*Thursday 20 June 2024*  
*CERN*

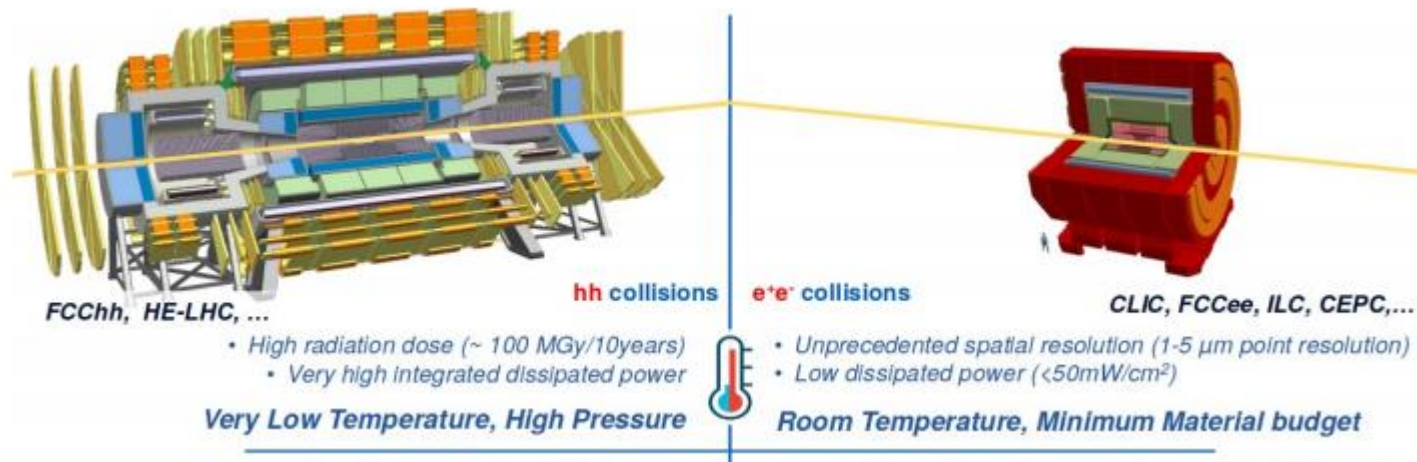
**WP 10**

**Advanced Mechanics for Tracking and Vertex Detectors**

**P. Petagna & M. Vos**



- WP10 aims at the development of technologies that can be implemented by the detector community for designs launched in the next 5-10 years



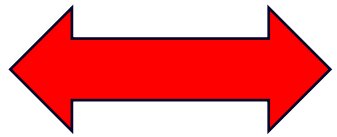
### Targeted applications

- Higgs Factories
- ALICE, LHCb LS3 pre-TDR, ATLAS & CMS LS4

- T10.2**
  - a. Bring to maturity **CMOS-compatible** Si- $\mu$ -channel fab processes
  - b. Exploit additive manufacturing for
    - Ultra-thin **metal** cooling devices
    - **Ceramic** (composites?) cooling devices
  - c. Develop ultra-light structures integrating cooling features
- T10.3** • Develop engineered solutions for hydraulic connections and interconnections (in particular introducing 3D printing)
- T10.4** • New approach to (natural) refrigerant fluids for warm and cold applications (**extension to cold after submission** thanks to synergies with external programmes)
- T10.5** • Develop instrumentation for accurate absolute position measurements on very small devices

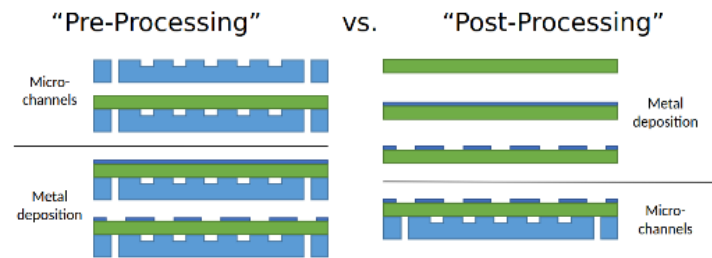
## Research institutes

## Advanced production centres



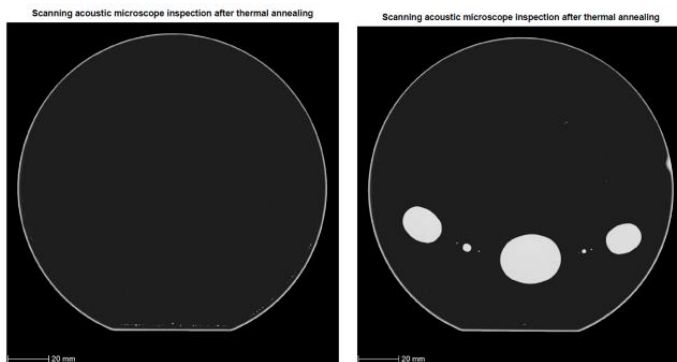
## Task 10.2: Engineering of optimised cooling substrates

### 10.2 a - Sculpting in silicon: Integrated micro-channels in silicon sensors



- **CMOS-compatible** process for wafer-level  $\mu$ -channel integration via anodic bonding **successfully integrated** in both “pre-processing” and “post-processing”
- **Now extending** to Si-Si bonding via interposition of a thin metal layer (**eutectic or thermocompression**)

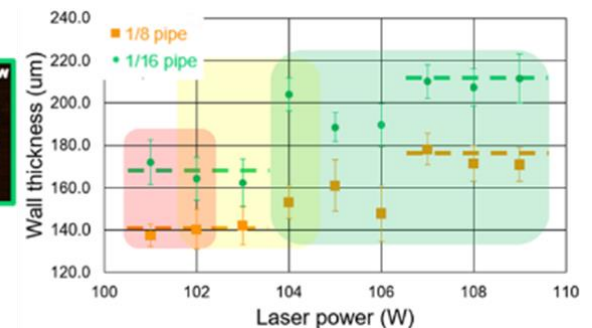
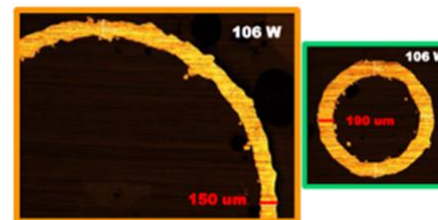
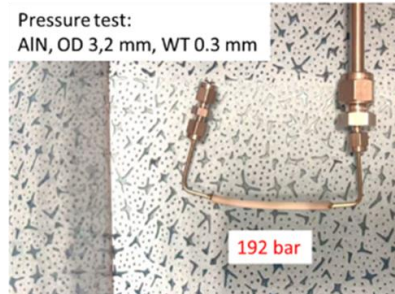
- **CMOS-compatible** plasma-activated / low temperature **direct Silicon bonding successfully demonstrated at unstructured wafer level**
- Encouraging preliminary results on structured wafers, but the move of the HLL semi-conductor laboratory to a new clean room and the complex tendering procedure for the new bonding machine are sensibly **delaying the progress**



## Task 10.2: Engineering of optimised cooling substrates

### 10.2 b - Ultra-light 3D-printed cold plates

- Definition of the attainable limits for thin-wall fluidic components produced by Additive Manufacturing in well-mastered materials ( $\text{Al}_2\text{O}_3$  and AlSi12) via process optimization: **COMPLETED**
- Exploring how the known techniques can be extended to materials that exhibit particularly interesting properties for detectors, but for which experience with 3D-printing is much less mature or basically inexistent (AlN and Kovar): **GOOD PROGRESS (in-schedule)**



## Task 10.2: Engineering of optimised cooling substrates

### 10.2 c - Ultra-light composite structures with fully integrated cooling

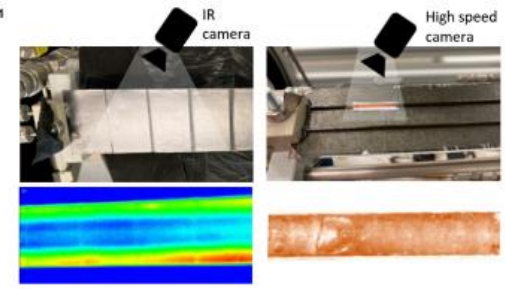
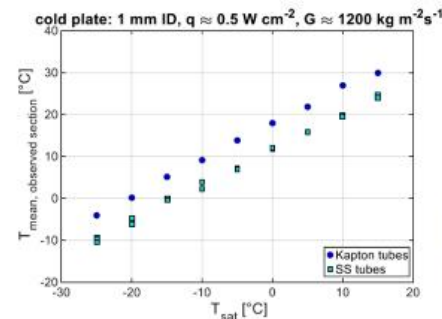
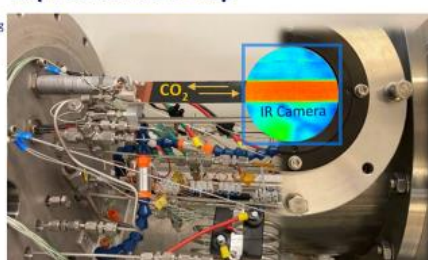
- **Achieved first demonstration of polyimide pipes integrated in ultra-light structure circulating (cold) boiling CO<sub>2</sub>** (publication being submitted)
- **Technology transfer** of the technology to the industrial partner (possible large-scale production) almost completed
- Alternative production technique by waterjet cut being investigated as well

#### Sample production

	Steel	Steel	Kapton	Kapton
ID [mm]	2.15	1	1.97	1.024
WT [mm]	0.51	0.29	0.17	0.076

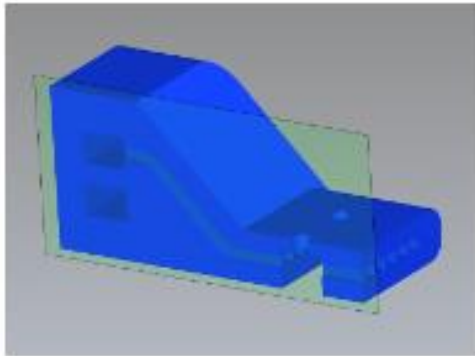


#### Experimental setup



## Task 10.3: Micro-connectivity

- Basic idea: engineer a 3D-printed prototype of “macro-to-micro” fluidic connector
- Important delays suffered due to hiring difficulties
- PEEK targeted as ideal material, but very difficult in 3D-printing for leak tightness
- Few in-house and outsourced trials provided negative results
- Positive contacts established with a very promising company could not be finalized
- Exploring now alternative (e.g. ceramic materials?)





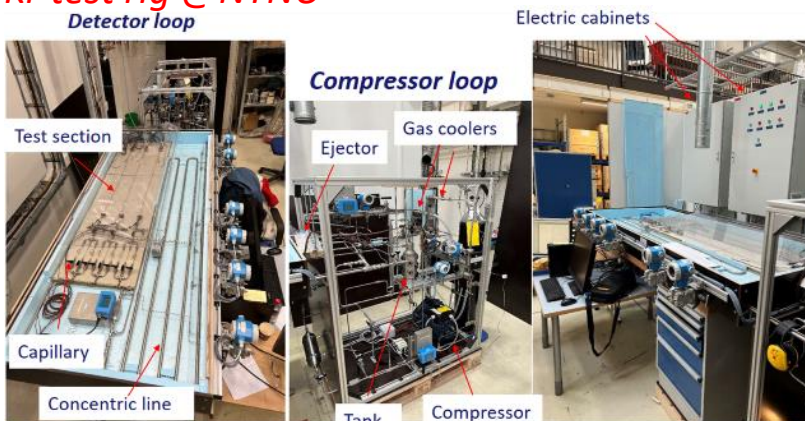
## Task 10.4: Supercritical CO<sub>2</sub> as refrigerant Addition: Super- and subcritical Kr as refrigerant

*sCO<sub>2</sub> test rig @CERN*



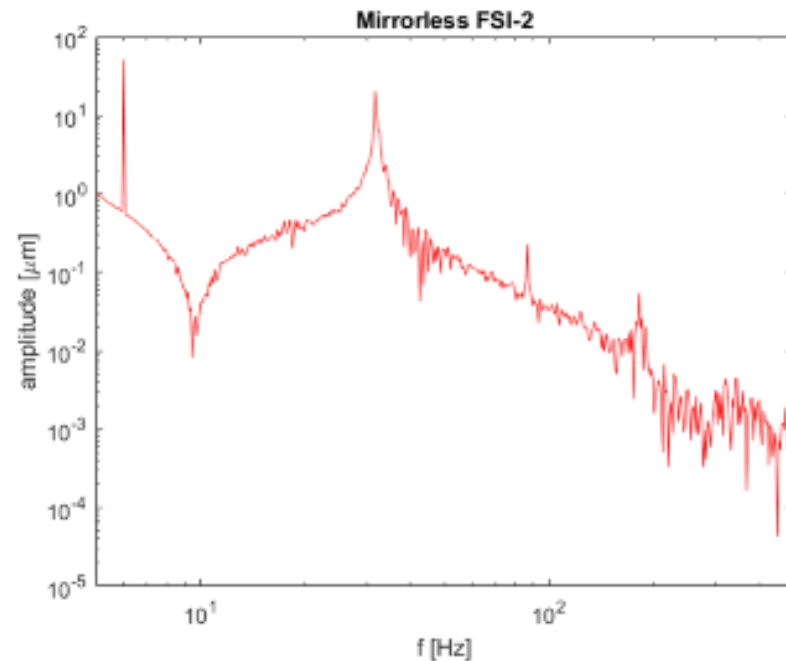
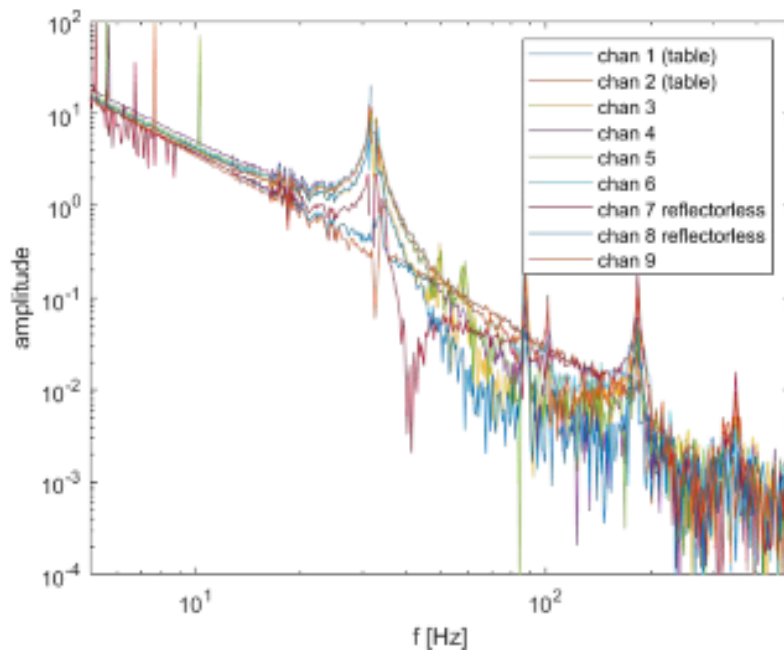
- 2PhD active
- Theoretical analysis completed
- Test rigs and DAQ almost completed
- Commissioning ongoing
- **Tests start in summer**
- **Publications being produced**

*Kr test rig @NTNU*



## Task 10.5: Characterisation of ultra-light structures

**First demonstration of mirrorless operation of the frequency scanning interferometry (FSI) system successfully achieved**



## List of deliverables

Deliverable Number <sup>14</sup>	Deliverable Title	Lead beneficiary	Type <sup>15</sup>	Dissemination level <sup>16</sup>	Due Date (in months) <sup>17</sup>
D10.1	Cooling device demonstrators	31 - CSIC	Report	Public	46
D10.2	Hydraulic interconnection technologies	8 - CNRS	Report	Public	43
D10.3	Supercritical CO2 as a refrigerant	26 - NTNU	Report	Public	44
D10.4	Upgraded FSI	42 - UOXF	Report	Public	45

## Description of deliverables

D10.1 : Cooling device demonstrators [46]

Set of at least three demonstrators, one per technology developed, accompanied by a report (Task 10.2)

D10.2 : Hydraulic interconnection technologies [43]

Report on validated technologies and their applications (Task 10.3)

D10.3 : Supercritical CO2 as a refrigerant [44]

Publication (submitted) on the use and properties of sCO2 as refrigerant (Task 10.4)

D10.4 : Upgraded FSI [45]

Feasibility study of new mirrorless FSI (Task 10.5)

- WP10 is globally well on track
- Four deliverables are due between M43 and M46
- Minor delays with the completion of the related reports are to be foreseen due to high workload on LHC experiment upgrades
- All planned deliverables are expected to be fulfilled
- The T10.2a part on (plasma-activated / low temperature) Si-Si bonding will probably be completed only beyond the nominal duration of the AIDAinnova project, as a consequence of the move of the HLL semi-conductor laboratory to a new clean room in Garching
- T10.3 will be probably forced to descope a bit the final results, due to difficulties experienced in hiring and to faced technical difficulties
- T10.4 will deliver much more than originally planned thanks to synergy with other programmes and injection of additional funds